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The Coming Ice Age

A true scientific detective story
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How a rising of the ocean waters may flood most of our port cities within the foreseeable future — and why it will be followed by the growth of a vast glacier which may eventually cover much of Europe and North America.

These two serious, careful scientists — geophysicist Maurice Ewing, director of Columbia University's Lamont Geological Observatory, and geologist-meteorologist William Donn believe they have finally found the explanation for the giant glaciers, which four times during the past million years have advanced and retreated over the earth. If they are right, the world is now heading into another Ice Age. It will come not as sudden catastrophe, but as the inevitable culmination of a process that has already begun in northern oceans.

As Ewing and Donn read the evidence, an Ice Age will result from a slow warming and rising of the ocean that is now taking place. They believe that this ocean flood — which may submerge large coastal areas of the eastern United States and western Europe — is going to melt the ice sheet which has covered the Arctic Ocean through all recorded history. Calculations based on the independent observations of other scientists indicate this melting could begin, within roughly one hundred years.

It is this melting of Arctic ice which Ewing and Donn believe will set off another Ice Age on earth. They predict that it will cause great snows to fall in the north — perennial unmelting snows which the world has not seen since the last Ice Age thousands of years ago. These snows will make the Arctic glaciers grow again, until their towering height forces them forward. The advance south will be slow, but if it follows the route of previous ice ages, it will encase in ice large parts of North America and Europe. It would, of course, take many centuries for that wall of ice to reach New York and Chicago, London and Paris. But its coming is an inevitable consequence of the cycle which Ewing and Donn believe is now taking place.

The coming of another Ice Age is an event serious scientists have never been able to predict from observable Earth phenomena. For until Ewing and Donn postulated their new Theory of Ice Ages (it was first published in Science in June 1956 and a second report appeared in May 1958) the very nature of the problem seemed to defy the kind of scientific understanding which makes prediction possible.

Scientists know that the glaciers which stand quiet in the Arctic today once covered America with a wall of ice up to two miles thick — its southern boundary extending from Long Island across New York, Pennsylvania, Ohio, Illinois, Wisconsin, Iowa, and the Dakotas to the Missouri River, with extensions into the western mountain country . . . that it covered northern Europe, England, large parts of France and Germany . . . that it created the Great Lakes, the Hudson and St. Lawrence Rivers . . . that it moved mountains, crashed down forests, destroyed whole species of life.

They also know that it is cold enough at the Arctic for glaciers to grow today, but almost no snow has fallen there in modern times. What caused those snows that built the Ice Age glaciers until their own height forced them to march, and what caused them finally to retreat? And why has the earth been swinging back and forth between Ice Ages and climate like today's for a million years, when before then the entire planet enjoyed a temperate climate with no extremes of hot or cold? Scientists could answer these questions only in terms of sudden catastrophe — a volcanic eruption, the earth's movement into a cloud of cosmic dust — and unpredictable catastrophes are not the concern of contemporary science. Few scientists had even worked on the problem in recent years.

It was only by a combination of lucky circumstance and persistent curiosity that Ewing and Donn as a team began working steadily on the Ice Age Mystery. As Director of Lamont Geological Observatory, located on top of the New York Palisades over the Hudson River, Ewing teaches theoretical geophysics and directs research in earthquake seismology, marine geology and biology, and oceanography. Donn teaches geology at Brooklyn College and directs the research in meteorology at Lamont. Since the two men live twenty miles apart and were occupied all day, they would often meet at eleven at night in a deserted laboratory at Columbia University — midway between their homes — and work into the morning on the Ice Age trail.

CLUES FROM SEA FOSSILS

THE two men share the scientist's passion for pure search, no matter where it leads. Ewing, a tall and powerful Texan who speaks in a gentle voice, was white-haired before he was fifty, a fact his friends attribute to the pace at which he has lived his life as a scientist. For a quarter-century he has been leading expeditions over the ocean, often risking his life while pioneering new methods of investigating its secrets. In the early 1930s he founded a new science by dropping charges from a whale boat and using a seismograph to identify the different layers of earth beneath the ocean. In 1955 he was given the Navy Distinguished Service Award for devising the SOFAR (Sound Fixing and Ranging) method for rescuing men from ships and planes lost at sea.

Donn, New York City bred, is a slight, wiry meteorologist, who tames tidal waves with logarithms. His mastery of the complex relationship between sea and weather complemented Ewing's knowledge of the depths of the oceans.

The original bits of information which set the two scientists onto the trail of the Ice Age Mystery first came to light on the decks of the three-masted schooner Vema which Lamont Observatory uses for scientific exploration. In the summer of 1953, the ship traced a puzzling pattern on the ocean bottom which led from the Atlantic to the Gulf of Mexico and into the Caribbean Sea. The Columbia-Lamont crew were working with their newly perfected "deep sea corer," a device which can bring up primeval sediment undisturbed through as much as 4,000 fathoms of water (24,000 feet) — just as it was deposited thousands of years ago.

This "corer" is a sharp-edged steel tube, two-and-a-half inches in diameter and up to 70 feet in length. When it has been lowered from the ship to within 15 feet of the sea bottom, a trigger trips the holding mechanism and the tube is punched by a weight into the sediment. The Lamont ocean expeditions have brought up cores as long as 60 feet — nearly 2,000 of them — representing the successive deposits of thousands of years. As Ewing describes it,

"The entire record of the earth is there in the most undisturbed form it is possible to find anywhere — traces of the animals, rocks, and plants of successive ages preserved in the order in which they filtered down from the surface of the sea."

Only recently, radioactive isotope techniques have made if possible to deduce when the sediment was deposited, and other things about the world from which it came. Scientists can now measure the radiocarbon in a sample of ocean-bottom mud — and know how long it has lain there. Radioactive carbon ceases to be replenished when removed from the atmosphere, and decays at a known rate. Chemists therefore calculate from the ratio of radiocarbon to ordinary carbon in a fossil shell whether it has been decaying for a thousand, five, or ten thousand years.

In these cores of mud from the Caribbean, the equatorial Atlantic, and the Gulf of Mexico that summer, the Lamont expedition kept seeing a strange sharp line. "About a foot below the floor of the ocean the sediment suddenly changed from salmon pink to gray," Ewing said. "You could see it sharp as a razor when the cores were opened on the ship's deck. Others had reported this same line in the North Atlantic.

"When we put these cores to paleontological laboratory tests back at Lamont, we found out what that razor-sharp line meant: at a certain time the ocean suddenly changed from cold to warm. The pink sediment contained shells of minute warm-water animals; the gray sediment, cold-water animals."

Back at Lamont, measurement of radiocarbon showed that this sudden warming took place throughout the length and breadth of the vast Atlantic Ocean — 11,000 years ago. The cores showed virtually no change in temperature for 90,000 years — except for this one sudden increase. Donn, Lamont's meteorological expert, was as mystified as Ewing.

"What happened 11,000 years ago to heat the ocean?" they kept asking themselves at odd moments over the next year or so. "What could change the climate of the whole ocean so abruptly?"

A JACKPOT IN ICE

NEITHER Ewing nor Donn can say precisely when the hunch came. The problem continued to tantalize them, as they traveled about the country attending meetings and doing field work. On the way back from Chicago, they may have watched the ice break up in the Delaware River. They recall reading a newspaper item about a big gambling jackpot on which day the ice would go out in the Yukon. The chain of thought seems obvious now: water freezing — ice going out — this is a sharp, abrupt change, the only sudden change that can happen to a body of water.

But oceans don't freeze. Ocean currents dissipate the cold — except, of course, in the small Arctic Ocean which is almost entirely surrounded by land.

"What would happen if the ice went out of the Arctic Ocean as it does in the Yukon or the Delaware?" Ewing and Donn remember wondering, as they went over the problem again, one day at Lamont.

"Well, we figured, the Arctic Ocean would get warmer. Because water would flow more freely between it and the Atlantic, dissipating the cold. And of course, the Atlantic Ocean would get colder. But wait a minute . . . we saw it simultaneously. If the Arctic Ocean were open water, warmed by the Atlantic, warmer than the land around it, water would evaporate and fall as snow on the land. More snow on Greenland and northern Canada would make glaciers grow. Glaciers don't grow now because there is no open water in the Arctic to provide the moisture for snow.

"And suddenly we had the startling hunch that the Arctic Ocean was open during the Ice Age. And that it froze over only 11,000 years ago. It was this freezing over of the Arctic Ocean which so suddenly warmed the Atlantic — and ended the Ice Age."

"That rather exciting ten minutes," they told me, "contradicted a whole lot of things we'd always taken for granted. Everyone has assumed that the Arctic Ocean, so covered with ice today, would be even colder and more completely frozen during an Ice Age.

"You get a lot of these wild ideas in our business. If one lasts five minutes you begin to take it seriously. The more we thought about this one, the more it added up. It explained so many things that have always puzzled us.

"For once you accept the radical idea that the Arctic was a warm open ocean at the time of the great continental glaciers, you can reconstruct a completely different weather pattern from the one we know today. As we worked it out, we could see a startling chain of cause and effect between the oceans and the glaciers themselves. We could see how the oceans would work as an actual 'thermostat' to keep the earth alternating between glacial ice ages and interglacial periods such as today.

"It all hinges on the fact that the North Pole is where it is — in the middle of the Arctic Ocean, which is almost completely surrounded by land except for a shallow 'sill' between Norway and Greenland opening into the Atlantic, and the insignificant Bering Strait. If the cold waters of the Arctic interchanged freely over this sill with the warm Atlantic water, the Arctic Ocean would not freeze over. Its moisture would build glaciers. (In the cold temperatures of the north, the moisture that evaporates from the open Arctic would all fall as snow — too much snow to melt in the short Arctic summer. When the rate at which snow accumulates exceeds the rate at which it melts, glaciers grow.) But as those glaciers grew, they would lock up so much ocean water that sea level would fall.

"We know that sea level was lowered between 300 and 400 feet at the peak of the last Ice Age. Now, most of that sill between Norway and Greenland is less than 300 feet deep. At a certain point the glaciers would lower the sea level so much that the Arctic Ocean would be virtually cut off from the warmer Atlantic. The Arctic Ocean would then freeze over. And the glaciers, no longer led by snow, would melt under the Arctic summer sun, restoring their water to the oceans. Then sea level would rise, until enough warm Atlantic water again flowed over that sill to melt the Arctic ice sheet, and start another glacial cycle."

Donn worked out a weather map of the world, with an open Arctic Ocean, warmer than surrounding lands. It showed a completely different storm pattern than exists today; more rain and snow in the Arctic, a wind pattern carrying more ocean moisture inland generally. It showed violent blizzards over eastern North America which would spread more snow on the glaciers. Summers would become more like winters as the glacial wall advanced southward. Donn's weather map with the open Arctic even showed that there would be rain in today's deserts.

But they needed more proof for their theory. They had to track down the circumstantial evidence of what happened 11,000 years ago; they had to find geological witnesses to confirm their reconstruction of the crime.

CLUES FROM A DROWNED RIVER

THEY embarked on the painstaking examination of the records of past Arctic explorers. There was little relevant data. One day, going through dusty old volumes of the National Geographic, they found a photograph of an Arctic beach — a beach that could have been made only by long years of pounding waves. There must have been open sea in the Arctic to make that beach.

Ewing took to sea in the Vema again. In the Gulf of Mexico, the Ice Age trail seemed to peter out altogether in a bottomless plain of flat gray silt. The Vema took core after core below the Mississippi Delta without finding the crucial fossil lines.

"We couldn't even get to the bottom of it with our corers," Ewing recalls. "We were sure the Gulf must have changed from cold to warm just as the other oceans, but how could we prove it when there seemed to be no fossils at all in that endless gray layer? We suspected that the gray silt had come from the Mississippi and had spread over the floor of the Gulf by creeping along the bottom. If we could find a hill that stood well above the Gulf floor, the sediment on top of it would have come down undisturbed from the surface of the water and might contain the record of those temperature changes."

They nearly sailed over them — a cluster of hills rising a thousand feet off the ocean floor. There, instead of puzzling gray silt, they finally found the familiar, razor-sharp layers of glacial and interglacial fossils.

And that very gray silt which had obscured their trail turned out to be further proof that 11,000 years ago was the date the Ice Age ended.

For back at Lamont, radiocarbon measurement showed that the silt stopped sliding from the Mississippi just 11,000 years ago. This meant that a great rise in sea level must have taken place at just that time. Drowned by the rising sea, the lower channels of the Mississippi River would retain their own sediment, losing the power to take it out to the deep central part of the Gulf, it was, almost certainly, the rise in sea level caused by the melting of the glaciers.

AND THE FISHBONE CAVES

AS THE Lamont crew were pursuing this mystery in the sea, other scientists were unearthing new Ice Age clues on land. Atomic Energy Commissioner Willard F. Libby, the scientist who originated radiocarbon dating, found fossils of a forest at Two Creeks, Wisconsin, that had been first flooded and then overridden by the advancing ice. Radiocarbon dating proved that those trees, at one of the southern fingertips of the last glacial advance, were pushed over about 11,000 years ago. (Previously, geologists thought the ice had disappeared long before that time.)

Then a series of dramatic clues were brought in by other geologists from caves in the cliffs above the dry Great Basin of Nevada and Utah. Several thousand feet above the basin are rock niches worn by the waves of glacial lakes — lakes created by the great rains that fell south of the Ice Age snows. Far below are caves, also worn by those waves, that were inhabited by man: the famous Fishbone Cave above the dry Winnemucca Lake in western Nevada and the Danger Cave above glacial Lake Bonneville in Utah.

The evidence showed that men moved into those caves shortly after the lake level suddenly dropped and exposed them. Remains were found of the nets and baskets they used to catch the fish of the now vanished glacial lakes. Radiocarbon dating showed that men were living in those caves — brought above the water when the great glacial rains and snows stopped — approximately 11,000 years ago. And the time during which the glacial lakes dropped from those niches thousands of feet above on the cliffs, to the level of the lower caves, was dramatically short — only several hundred years. It was like the sudden change Ewing and Donn had observed in the ocean. The date was now established: 11,000 years ago, plus or minus a few hundred years, the last Ice Age suddenly ended.

At the time the theory was constructed, there was no actual evidence from the Arctic Ocean itself to indicate it had ever been ice-free. Some months later Dr. A. P. Crary came back from the Arctic Ocean and sent his cores to Lamont. These cores indicated there had been minute animal life for thousands of years in the Arctic Ocean, which suddenly stopped — eleven millenniums ago. They also showed evidence of icebergs free to move in open water at the time Ewing and Donn think the Arctic was open.

BEYOND THE NORTH WIND

COULD men have lived on the shores of this ocean during the Ice Age? Were there human witnesses to the open Arctic sea?

“It was only by accident that we stumbled on a vital clue in a completely different branch of science,’’ they told me. “We might have missed it altogether because of the compartmentalization of science.”

One day a colleague of Donn’s happened to remark over coffee that he’d overheard an anthropologist in the faculty room talking about some traces that had just been discovered of an ancient civilization around the Arctic.

Donn and Ewing started calling anthropologists. The evidence was uncertain, they learned, but some of it pointed strongly to well-established communities of man around the Arctic many thousands of years ago. In fact, the oldest flints showing man in America had been found recently in a band around the Arctic Circle, seldom straying south.

Anthropologists had been mystified. Even if a land bridge between Siberia and Alaska had existed then, why would man choose to use it to settle in the Arctic Circle, in the very heart of the intense polar cold, at temperature which was assumed to be even lower than today? Around that frozen Arctic Ocean, where would man have found the fish and game those flints suggested? Why would men have stayed there for centuries — unless, as Ewing and Donn now believe, the Arctic Ocean was open then, and its shores were a warm oasis compared with the glaciers to the South?

Ewing and Donn got another anthropologist out of bed late at night to question him further. He told them that, while anthropologists are still uncertain as to how and when man first came to America, they are pretty sure he suddenly started migrating south, in an explosive wave, about 11,000 years ago.

Here, perhaps, were their human witnesses to the end of the Ice Age! The people who lived "beyond the north wind'' on Arctic shores, behind the towering wall of ice, using their flint-tipped weapons on big game and fish that could not survive in the cold Arctic temperatures of today. These men evidently came to America from Siberia when the glaciers had taken enough water from the sea to uncover the Siberian land bridge. They stayed for some centuries around the warm Arctic because the glaciers kept them from straying south. Then, 11,000 years ago, they suddenly fled. If the Arctic Ocean suddenly froze over, they couldn't eat. Nor could they go back to Siberia because the great rise in sea level at the end of the Ice Age would once more submerge the land bridge.

And just at the time when they could no longer stay in the Arctic, paths opened in the great ice wall south of them. The melting glaciers permitted men to go south at last — in such a rapid wave that they reached the tip of South America in a few thousand years.

So anthropologists are now reconstructing their own mysteries in the light of Ewing and Donn's Theory of Ice Ages — which California's authority on early man, Carl Sauer, calls "a major contribution to our understanding. . . . The old, simple belief that man waited at the threshold of the New World until the last ice sheet was gone has been proved wrong."

And, finally, human witnesses were tracked down in southern deserts. During this past year archaeologists have brought back new evidence that the Sahara desert was green and fertile and thriving with civilization when glaciers froze life in America and Europe. Ewing and Donn had deduced that an open Arctic Ocean would have caused rain in today's deserts. Now, from the caves of the Sahara, came ancient man's vivid drawings of the animals that he hunted on the once grassy desert.

BENEATH THE EARTH'S CHUST

ONE big question remained which the new theory did not seem to answer: What started off the first Ice Age cycle?

"We know that during the past million years, the world has swung back and forth between ice ages and weather like today's," Ewing and Donn told me. "Before then, the whole earth was much warmer. There were no zones of extreme heat or cold; palms and magnolias grew in Greenland, and coral around Iceland; subtropical plants thrived within eleven degrees of the North Pole. Why didn't the Arctic Ocean-glacier 'thermostat' work then? What suddenly turned it on one million years ago?

"The answer, we believe, is chat until a million years ago, the North Pole was not in that landlocked Arctic Ocean at all, but in the middle of the open Pacific, where there was no land on which snow and ice could accumulate, and ocean currents dissipated the cold.

"The idea of wandering poles may seem fantastic. But recently-discovered magnetic evidence leads to the geological inference that the whole earth can shift its surface crust with respect to the interior. As the earth's crustal zone 'slides' over the interior, different points on the surface can be at the North or South Pole.

"Such a shift in the earth's crust, it is now believed, did take place before the first Pleistocene fee Age which began a million years ago. Before then, the magnetic record shows the North Pole in the middle of the Pacific, and the South Pole in the open southern Atlantic.

"An abrupt shift in the earth's crust carried the North Pole into the small and virtually landlocked Arctic, and the South Pole to the Antarctic continent, where the polar cold could not be dissipated by free ocean currents. That started the greatly contrasting zones of climate we know today — and the concentration of cold which finally froze the Arctic Ocean, to start the Ice Age cycles."

This would explain why the Ice Age glaciers have always marched from the Arctic. No ocean thermostat exists to turn on drastic glacial-interglacial cycles in the Antarctic. There, according to the theory, the Antarctic ice cap has been building up continually since the South Pole shifted to that continent a million years ago, with only minor changes caused by the slight warming and cooling of the Atlantic in the glacial-interglacial cycles. This is confirmed by evidence from elevated beaches, which seems to indicate that maximum sea level has been dropping successively lower in each glacial era.

And as long as the poles stay where they are, the Ice Age cycles must continue.

WHEN WILL IT COME AGAIN?

EWING and Donn realized that their theory had startling implications for the future. They have the scientist's distaste for the sensational and carefully worked out the wording of the theory's formal conclusion: "The recent epoch can be considered as another interglacial stage." A number of scientists have tried to disprove their theory; so far they have been unsuccessful.

As Ewing and Donn read the glacial thermostat, the present interglacial stage is well advanced; the earth is now heading into another Ice Age. Certain signs, some of them visible to the layman as well as the scientist, indicate we may have been watching an Ice Age approach for some time without realizing what we were seeing.

Although scientists do not agree on its significance, they have observed an increasingly rapid warming and rising of the ocean in recent years. Warm water flowing north has driven the codfish off Cape Cod to Newfoundland; annual temperature has risen ten degrees in Iceland and Greenland; down here winters are warmer; the Hudson River no longer freezes over as it used to. It is part of the Ewing-Donn paradox that the next Ice Age will be preceded by such a warming of climate.

"We suspect that the ocean is already warm enough to melt the Arctic ice sheet," Ewing and Donn told me. "For some time it has remained at the highest temperature ever reached in the four previous interglacial stages." As climate becomes warmer, more and more glacial melt-water pours into the sea. The Atlantic has already risen 300 feet since the glaciers of the last Ice Age started to melt away. Up until twenty-five years ago the U.S. Geodetic Surveys indicated that sea level was rising six inches a century; in the past twenty-five years that rate has increased to two feet a century.

As sea level rises, more and more warm water pours over the Norway-Greenland sill, under the Arctic ice sheet. American, Russian, and Scandinavian scientists have observed a definite warming of the Arctic Ocean over the past fifty years, and a consequent thinning of the ice sheet. At an international conference on Arctic sea ice in March 1958, scientists estimated that Arctic ice covers an area 12 per cent smaller than it did fifteen years ago, and is 40 per cent thinner. A layman might surmise that if this trend continues the Arctic Ocean will be open and the Ice Age begin in another twenty years. Ewing and Dunn are much more cautious about predictions.

"The rate at which our weather has been warming in recent years could be temporarily slowed down," they told me. "We don't know the exact rate at which the sea is now rising. We need long-term world-wide evidence which the International Geophysical Year may give us to assess accurately the changes that seem to be taking place in the ocean and the ice."

If the ocean continues to warm up at the present rate, Ewing and Donn think it is conceivable that there will be open water in the Arctic within about a hundred years. If they are right, tor the first time in the history of the world, the victims of an Ice Age are going to see it coming. Television cameramen will be raging all over the far north, covering the break-up of the Arctic ice sheet, looking for the first dirty summer slush. For the Ice Age will dawn, not in crashing glacial terror but in slush; as Ewing and Donn describe it, on a summer vacation up north, you will simply see a lot of dirty slush, winter's snow that for the first time in thousands of years didn't quite melt.

In many parts of America, at that time, the worry may not be ice, but water. Many scientists have speculated on the ocean flood that will be caused if the melting of glacial icecaps continues. Antarctic scientist Laurence Gould recently warned that "the return of only a few feet of thickness of ice as melt-water to the oceans would have serious effects in many places; and if all the ice were melted into the sea, its level would rise from 150 to 200 feet. All the world's seaports and some of its most densely populated areas would be submerged."

Ewing and Donn don't know how much higher the sea is going to rise before it melts the Arctic ice sheet. They say the ocean has already risen to the point where, if certain recent storms had occurred at high tide, it would have flooded New York and Boston subways. Donn is now working at Lamont on studies of long and short period changes in world sea level.

The ocean flood that brings about the Ice Age will not resemble the flash floods that have caused havoc in the cast in recent years. It will build up slowly, and it will not flow away. The cities, industries, and military bases that are concentrated on both sides of the Atlantic may have to be evacuated. (Fortunately, Pacific coastlines are higher.)

It will probably be possible to protect New York and Washington by levees. Parts or all of New Orleans, Amsterdam, Rotterdam, and other cities are now protected by levees from high water, Ewing and Donn point out. Evidently, New York is in no danger of becoming a lost Atlantis, drowned under the sea. If low-lying Brooklyn, Miami, Washington, New Orleans, or Amsterdam should become ghost cities, it will be because a decision will have been made long in advance of this slow-creeping flood to evacuate rather than build levees.

"According to our theory, with the melting of the Arctic ice sheet, the rise in sea level will stop," Ewing and Donn explained. Instead of adding water to the sea, the glaciers will begin taking it out.

For a long time after the ocean flood subsides, the only effect the Ice Age will have on us down here will be more rain. The new Arctic moisture that falls as snow on the glaciers will increase both rain and snow here, swelling rivers and watering deserts. Then, gradually, our weather will cool. Icy winds will blow from the advancing glaciers; the great snows will fall farther and farther south. In several thousand years a two-mile ice sheet may cover the United States and Europe. If man finds no way to switch the glacial thermostat, there may well be a real estate boom in the Sahara.